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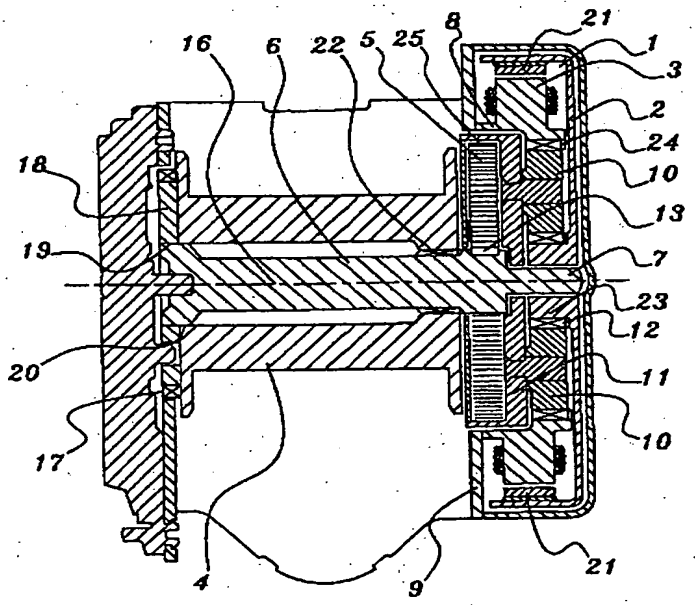

(57) Abstract: A seatbelt retractor has a belt reel (4) which rotates about an axis (16) mounted n a frame (9). A drive spring (5) drives the belt reel in the winding-on direction. A blocking device blocks the belt reel to prevent belt extension, and an electric motor (1) influences various functions of the seatbelt retractor. A rotor (2) can be selectively brought into driving relationship with the drive spring, a torsion bar (6), and the belt reel.

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SEATBELT RETRACTOR

The invention concerns a seatbelt retractor as set forth in the characterizing portion of claim 1.

In a seatbelt retractor of that kind which is known from DE 41 12 620 A1, the winding-on spring is so acted upon by an electric motor that, after the seatbelt is fitted, the fitting force applied to the seatbelt webbing becomes less than that applied to the seatbelt webbing when it is pulled out into the parking position. For that purpose the electric motor acts on the rotatably mounted spring casing on the seatbelt retractor.

In a further seatbelt retractor known from DE 27 42 676 an electric motor is provided at the spring side of the seatbelt retractor, and acts on the drive spring by a clutch. That makes it possible to adjust the return force of the drive spring. The clutch can be in the form of a slipping clutch in order to limit the torque transmitted by the electric motor (control motor) to a maximum value.

The object of the present invention is to provide a seatbelt retractor of the kind set forth in the opening part of this specification, in which the seatbelt retractor provided with the electric motor, while being of a compact structure, performs further functions.

In accordance with the invention that object is attained by the characterizing features of claim 1.

The invention provides for using a torsion bar arranged as a load limiting means in the axis of the belt reel, for mounting the rotor, with which the control movement for varying the drive spring force is transmitted. For that purpose the electric motor can

be arranged with its output shaft parallel to the axis of the belt reel. For that purpose the output shaft of the electric motor can be rotatably drivably connected to the rotor by a transmission arrangement, for example in the form of pulling means, toothed belts, chains, metal belts, gear transmission arrangements and the like.

In addition the rotor and the stator of the electric motor can be arranged in concentric relationship with the shaft of the belt reel at the spring side of the seatbelt retractor. For that purpose, for adjustment of the force of the drive spring, the rotor is rotatably connected to at least one of the two ends of the drive spring. That rotary connection is in particular a rigid rotary connection without the interposition of a slipping clutch. It is possible to provide a transmission arrangement, in particular a planetary transmission arrangement, between the rotor and the spring-engagement point.

A suitable electric motor is a flat motor as described in DE 43 02 042 A1. That electric motor which is of a flat structure has stator poles on an inwardly disposed radius and rotor poles on an outwardly disposed radius around the stator poles. The axial extent of the rotor-stator assembly is substantially smaller than the outside diameter of the rotor. A planetary transmission arrangement of a compact structure can be arranged within the stator poles, the planetary transmission arrangement being rotatably drivingly connected to the rotor. The rotary movement which is transmitted by the planetary transmission arrangement can be transmitted to the drive spring or by a clutch to a load limiting means and/or the winding shaft. It is also possible for the

rotary movement of the rotor to be transmitted directly to one of the two ends of the drive spring. Preferably, transmission is to the outwardly disposed end of the drive spring.

The specific arrangement of the components of the electric motor and a planetary transmission arrangement which is possibly advantageously integrated affords the possibility of additional functions also being implemented by the seatbelt retractor, in comparison with the state of the art. Such functions are, besides adjustment of the level of comfort involved in wearing the seatbelt webbing, by virtue of suitable adjustment of the drive spring return force, a belt pretensioning effect which can be triggered by a pre-crash sensor or emergency braking. Belt pretensioning of that kind, below the triggering threshold for full-action tensioning, gives the vehicle occupant a feeling of safety in situations involving heavy braking or in the early stage of a crash or in accident-prone road situations, in all directions of deceleration. For that purpose for example the drive spring can be wound by the electric motor to a blocked condition and the continuing torque is transmitted by the spring which has been wound to a blocked condition, to the belt reel for pretensioning the seatbelt. It is also possible for that rotary movement to be transmitted to the belt reel by an engaged clutch.

There is also the possibility of providing an adjustable load limiting means by the combination of a predetermined load limiting means which is preferably in the form of a torsion bar with the torque furnished by the electric motor. Depending on the severity of a crash and/or vehicle occupant data (5th percentile

women to 95th percentile men) it is then possible for the retaining force to be suitably adjusted with active belt shaft blocking for a limited degree of belt webbing extension.

The combination of the torque supplied by the electric motor with the energy absorption effect afforded by the load limiting means, in particular the torsion bar, when belt webbing extension is braked, can be achieved by the drive spring when wound to a blocked condition or by an engaged clutch which is operatively disposed between the rotor or the planetary transmission arrangement and the winding shaft and/or the load limiting means, in particular a torsion bar. The torque of the electric motor can increase or reduce the effect of energy absorption, which is predetermined by the load limiting means, in particular the torsion bar. This load limiting dependse on the severity of the crash and the data relating to the vehicle occupants. For that purpose the electric motor can be controlled in particular by belt force characteristic curves of a performance graph (DE 196 40 842 A1 and DE 197 31 689 A1).

Advantageously, functional parts such as for example the load limiting means which is in the form of a torsion bar can serve to support components of the electric motor, in particular the rotor. For that purpose, the torsion bar can be provided with an axially extending extension portion on which the rotor is mounted. For that purpose the torsion bar is arranged in the axis of the belt reel. In addition the stator of the rotor can be mounted on the frame of the seatbelt retractor, in particular the frame limb at the spring side. Preferably the stator carrier can be formed in one piece with that frame limb.

Brief Description of the Drawings

The invention will be described in greater detail hereinafter by means of embodiments with reference to the Figures in which:

Figure 1 shows a first embodiment,

Figure 2 shows a second embodiment,

Figure 3 shows a clutch used in the second embodiment,

Figure 4 shows a third embodiment, and

Figure 5 shows a fourth embodiment.

Detailed Description of the Invention

The embodiments of seatbelt retractors shown in the Figures each have a belt reel 4 for a seatbelt (not shown). A drive spring 5 drives the belt reel in the winding-on direction in known fashion. A blocking pawl (not shown) which is actuated by an acceleration sensor can engage into a blocking tooth arrangement 17. The blocking tooth arrangement is disposed on a blocking disc 18 which in the normal winding-on and unwinding mode of operation, rotates about an axis 16, together with the belt reel 4. When the blocking pawl engages into the blocking tooth arrangement the belt reel is blocked to prevent further rotary movement thereof on a frame 9 in which the belt reel is rotatably supported.

An electric motor 1 is disposed at the spring side of the frame 9. A stator 3 of the electric motor is supported on the frame by a stator carrier 8. The stator carrier can possibly be formed in one piece with the frame. The stator 3 is arranged on an inwardly disposed radius and a rotor 2 of the electric motor is disposed on an outer radius. Poles 21 of the rotor are disposed in opposite relationship to the poles of the stator 3, in one plane. The stator carrier 8 and the stator 3 are of an annular configuration. Disposed in the interior of the annular configuration is a planetary or epicyclic transmission arrangement comprising epicyclic gears 10 which are mounted rotatably on an epicyclic gear carrier 11. The carrier is rotates about the axis 16 of the belt reel 4.

In the illustrated embodiments, disposed in the axis 16 of the belt reel 4 is a load limiting means in

the form of a torsion bar 6. The torsion bar extends in the axial direction. In the proximity of the spring side, the torsion bar is non-rotatably connected to the inside of the belt reel by a positively locking connection indicated at 22. At the other side (mechanism side) of the seatbelt retractor, the torsion bar 6 is non-rotatably connected to the blocking disc 18 by a fixed mounting 19. Beside the fixed mounting the torsion bar forms with the inside of the belt reel 4 a loose mounting 20 which permits rotary movement of the belt reel with respect to the loose mounting portion formed by the torsion bar. In the normal winding-on and unwinding mode of operation of the belt reel 4, the torsion bar 6 rotates together with the belt reel about the axis 16.

In the illustrated embodiments the drive spring 5 is non-rotatably connected to the torsion bar 6 by a spring core or tongue portion 13. In normal operation the return force of the drive spring is thus transmitted by the torsion bar to the belt reel.

The torsion bar 6 has an axial extension portion 7. The rotor 2 of the electric motor 1 is rotatably mounted on the extension portion. In the illustrated embodiments the rotor is of a cap-shaped configuration. A mounting extension portion 23 which projects inwardly at the centre has on its outside a tooth arrangement forming a sun gear 12 of the planetary transmission arrangement. The epicyclic gears 10 mesh with that sun gear. To complete the planetary transmission arrangement, the stator 3 is provided at its internal periphery with a tooth arrangement forming an annular gear 24 into which the epicyclic gears 10 engage. A flat motor with integrated planetary transmission, which is used

in the illustrated embodiments, is known from DE 43 02 042 A1.

The electric motor 1 which for example is in the form of a dc motor is coupled or is coupleable to the various components of the seatbelt retractor in such a way that various functions of the seatbelt retractor are suitably implemented depending on the respective situation in terms of travel movement or operation.

In the embodiment shown in Figure 1, the torque of the rotor 2 is transmitted by the planetary transmission arrangement and the epicyclic gear carrier 11 to an external attachment point 25 of the drive spring 5. In that way it is possible for the return force of the drive spring to be adjusted depending on the respective operating situation involved. For example, the return force of the drive spring can be increased for winding on the seatbelt webbing into the park position, thereby providing that the belt webbing is quickly wound on to the belt reel 4. To improve the level of seatbelt-wearing comfort and convenience, the return force of the drive spring 5 can be reduced when fitting the seatbelt in position and when the seatbelt is fitted.

In addition, the drive spring 5 can be wound to a blocked condition by the electric motor 1 which for example is in the form of a dc motor. For example in a pre-crash situation pretensioning of the seatbelt can be effected in that way by the torque continuing to act.

In the event of a crash, with the belt reel in a blocked condition upon forward displacement of the vehicle occupant the action of the load limiting means which is in the form of a torsion bar 6 can be suitably adjusted by variable additive torque

regulation of the electric motor 1. The action of the torsion bar can be weakened or increased in that way, depending on the direction of rotation of the rotor 2. In that way, it is possible to achieve a characteristic curve-controlled load-limitation effect in dependence on severity of a crash and size and weight of the vehicle occupants. When acting as a load limiting means, the blocking disc 18 is prevented from further rotational movement by virtue of the blocking pawl engaging into the blocking tooth arrangement 17. The end of the torsion bar 6, which is connected to the blocking disc by the fixed mounting 19, is also prevented from rotating. The belt reel 4 however can rotate in the loose mounting 20 with respect to the torsion bar. As the positively locking connection 22 in the proximity of the spring side between the torsion bar and the belt reel 4 is retained, the torsion bar 6 twists in itself and acts as a load limiting means. As already mentioned, that also acts from the electric motor 1 by the drive spring 5 which is wound to a blocked condition on the end of the torsion bar which is connected to the drive spring by the spring core or tongue portion 13. Preferably the spring core or tongue portion is disposed in the immediate proximity of the positively locking connection 22 between the belt reel 4 and the torsion bar. In the embodiment shown in Figure 1 the drive spring 5 is disposed within the stator carrier 8 and between the planetary transmission arrangement and the end face, at the spring side, of the belt reel 4. The spring casing in which the drive spring is arranged can be formed in one piece with the epicyclic gear carrier 11. It can however also be produced as a separate item and non-

rotatably connected to the epicyclic gear carrier. The connection between the drive spring 5 and the epicyclic gear carrier is such that, as already mentioned, the torque produced by the electric motor 1 can be transmitted to the outer attachment point 25 of the drive spring.

In the embodiments illustrated in Figures 2 and 4 the drive spring 5 is disposed outside the rotor 2 which is of a cap-shaped configuration. The spring casing in which the drive spring is arranged can be formed or shaped on the rotor or it can be non-rotatably joined to the rotor. The spring core or tongue portion 13 is non-rotatably connected to the axial extension portion 7 of the torsion bar 6. In the embodiments of Figures 2 and 4 that extension portion extends through the rotor. The spring core or tongue portion 13 is connected to the part of the extension portion, which projects through the rotor.

The outer attachment point 25 of the drive spring 5 is directly connected to the rotor 2. That can be effected by the spring casing to which the outer attachment point of the drive spring is mounted being non-rotatably connected to the rotor. It is however also possible for a casing-like spring-receiving means to be formed or shaped integrally on the rotor, in which case the outer attachment point 25 is provided on that spring-receiving means on the rotor.

As already described in relation to the embodiment of Figure 1 the torque which is produced by the electric motor 1 is caused to act on the drive spring 5. In this respect, the return force of the drive spring can be adjusted in the same manner as already discussed above for achieving the required

level of comfort and convenience in terms of wearing the seatbelt webbing. The drive spring 5 can also be wound to a blocked condition and the functions, described in connection with the embodiment of Figure 1, of seatbelt pretensioning in a pre-crash situation or influencing the load-limiting behaviour of the torsion bar 6 can be implemented.

It is however also possible to provide additional clutches, as are shown in the embodiments of Figures 2 and 4.

In the embodiment shown in Figure 2, provided between the belt reel 4 and the epicyclic gear carrier 11 is a clutch 14 which is diagrammatically shown in plan in Figure 3. The clutch is a roller-type clutch. In the normal mode of seatbelt retractor operation clutch rollers 26 are disposed in a radially outward position with respect to the axis 16 of the belt reel. In that position, the clutch rollers are released from the epicyclic gear carrier 11 and connect a ring 27 carrying the blocking tooth arrangement 17 to an annular body flange 28 which is formed integrally on the end face of the belt reel 4 and extends around the axis 16. In that position, the blocking tooth arrangement is non-rotatably connected to the belt reel. The clutch rollers assume that position in normal operation of the seatbelt retractor. In this embodiment, the belt reel 4 can be blocked at both sides in the two blocking tooth arrangements 17, in normal operation of the seatbelt retractor. In the event of a crash blocking pawls engage into the two blocking tooth arrangements, possibly after implementing full-power tensioning of the seatbelt. Upon forward displacement of the vehicle occupant into the seatbelt which is blocked to prevent belt webbing

extension, a relative rotary movement occurs between the ring 27 and the flange 28, and that relative rotary movement causes the clutch rollers 26 to be moved radially inwardly with respect to the axis 16, in known manner, as is described for example in DE 196 47 841 A1, so that the clutch rollers come into engagement into corresponding openings 29 in the epicyclic gear carrier 11 or an output drive portion integrally connected thereto. In that radially inward position the epicyclic gear carrier or the output drive portion which is integrally or non-rotatably connected thereto and the flange 28, that is to say the belt reel 4, are non-rotatably coupled together.

In Figure 2 the left-hand end of the torsion bar 6, as already discussed above, is prevented from rotating by the fixed mounting 19 and the blocked blocking disc 18. At the right-hand side (spring side) there is the positively locking connection 22 between the belt reel 4 and the torsion bar. The belt reel can rotate with respect to the blocked ring 27. In addition, the load-limiting action of the torsion bar can be influenced by a torque produced by the electric motor 1 by the planetary transmission arrangement, by virtue of the clutch engagement between the flange 28 and the epicyclic gear carrier. Rotary movement of the belt reel with respect to the torsion bar is made possible by virtue of the loose mounting 20 at the left-hand side of the belt reel. The load-limiting action of the torsion bar 6 can be influenced by the torque furnished by the electric motor 1, by the clutch engagement and the positively locking connection 22 between the belt reel 4 and the torsion bar.

The embodiment shown in Figure 4 also involves the use of a clutch 15 which is engaged by virtue of the relative rotary movement of two parts which are to be connected together. In this case, it is possible to use a clutch pawl as is known for example from DE 35 31 856 A1. A coupling engagement is produced by the clutch 15 between the epicyclic gear carrier 11 which transmits the torque of the electric motor 1 and a clutch tooth arrangement 30 provided at the periphery of the torsion bar 6, when the epicyclic gear carrier is turned by the electric motor with respect to the torsion bar. Possibly, that can provide for transmission of a torque which is required for a pretensioning effect by the torsion bar and the positively locking connection 22 between the torsion bar 6 and the winding shaft 4, to the winding shaft. The clutch 15 can operate in the manner described in DE 198 44 092 A1. For that purpose the clutch pawl is disposed in a clutch housing 31 which is non-rotatably connected to the epicyclic gear carrier 11.

Furthermore, upon clutch engagement, the torque supplied by the electric motor 1 can be used additively in relation to the load-limiting effect of the torsion bar 6. As also in the case of the embodiments of Figures 1 and 2, it is possible in that way to provide for a characteristic curve-controlled force-limitation effect in dependence on the severity of a crash the body weight and dimensions of the vehicle occupants.

In the embodiment illustrated in Figure 5 the electric motor 1 is arranged with its rotor shaft substantially parallel to the belt reel axis 16. An output shaft 33 of the electric motor is connected to a cap-shaped rotor 32 by a transmission arrangement

which can be a gear transmission arrangement, a transmission arrangement involving pulling means, a toothed belt, chain, metal belt or the like. The cap-shaped rotor 32 is designed and supported in the same manner as the rotors of the embodiments of Figures 2 and 4. In the illustrated embodiment the gear transmission arrangement comprises a gear 34 which is carried on the output shaft 33 and an intermediate gear 35 meshing with the gear 34 and an external tooth ring on the rotor 32. The clutch 14 is of the same design as in the embodiment of Figures 2 and 3.

The electric motor is preferably fixed at the stator side to two limbs of the frame 9.

In order to ensure that the rotor 32 retains the angular position set by the electric motor 1, a self-locking retaining device 36 can act on the rotor. The retaining device can be in the form of a self-locking transmission arrangement which for example transmits the rotary movement of the rotor 32 to a rotary angle sensing device 37. The rotary angle sensing device can be in the form of a potentiometer which produces an electrical signal corresponding to the angular position of the rotor. It is however also possible for the transmission arrangement which transmits the drive movement of the electric motor 1 to the rotor 32 to be of a self-locking nature. That ensures in particular that the return force of the drive spring 5, which is set by the electric motor, is maintained with the value as set.

Claims:

1. A seatbelt retractor comprising a belt reel for a seatbelt, which is mounted on a frame rotatably about an axis, a drive spring which drives the belt reel in the winding-on direction, a blocking device for blocking the belt reel to prevent belt webbing extension, an electric motor influencing functions effected by the drive spring, and a rotor which is arranged concentrically with respect to the axis of the belt reel at the spring side of the seatbelt retractor and which for adjustment of the force of the drive spring is rotatably connected to at least one of the two ends of the drive spring, characterized in that arranged in the axis (16) of the belt reel (4) as a load limiting means is a torsion bar (6) having an extension portion (7) which extends in the axial direction and on which the rotor (2; 32) is mounted.

2. A seatbelt retractor according to claim 1 characterized in that the electric motor (1) is arranged with its output shaft (33) parallel to the belt reel axis (16).

3. A seatbelt retractor according to claim 1 or claim 2 characterized in that a transmission arrangement (34, 35) is arranged between the output shaft (33) of the electric motor (1) and the rotor (32).

4. A seatbelt retractor according to claim 1 characterized in that the rotor (2) is in the form of the rotor of the electric motor (1) whose stator (3)

is arranged in concentric relationship with the axis (16) of the belt reel (4).

5. A seatbelt retractor according to one of claims 1 to 4 characterized in that the electric motor (1) is supported at the stator side on the frame (9) of the seatbelt retractor.

6. A seatbelt retractor according to one of claims 1 to 5 characterized in that disposed in the rotor (2; 32) is a planetary transmission arrangement (10; 12) with which the torque of the rotor (2; 32) can be transmitted to the torsion bar (6) and/or the belt reel (4).

7. A seatbelt retractor according to claim 6 characterized in that an epicyclic gear carrier (11) of the transmission arrangement (10; 12) is rotatably supported on the axial extension portion (7) of the torsion bar (6).

8. A seatbelt retractor according to one of claims 1 to 7 characterized in that the drive spring (5) can be wound to a blocked condition by the electric motor (1).

9. A seatbelt retractor according to one of claims 1 to 8 characterized in that the drive spring (5) when wound to a blocked condition non-rotatably connects the rotor (2; 32) to the torsion bar (6) and/or the belt reel (4).

10. A seatbelt retractor according to one of claims 1 to 9 characterized in that the torque of the

rotor (2; 32) can be additively and/or subtractively transmitted by the planetary transmission arrangement (10; 12) to the torsion bar (6) and/or the belt reel (4).

11. A seatbelt retractor according to one of claims 1 to 10 characterized in that the drive spring (5) is arranged between the rotor (2; 32) and the torsion bar (6).

12. A seatbelt retractor according to claim 11 characterized in that a spring core portion (13) of the drive spring (5) is non-rotatably connected to the torsion bar (6).

13. A seatbelt retractor according to claim 11 or claim 12 characterized in that the torque of the rotor (2; 32) can be transmitted by the planetary transmission arrangement (10; 12) to the drive spring (5).

14. A seatbelt retractor according to one of claims 1 to 13 characterized in that a sun gear (12) of the planetary transmission arrangement (10; 12) is non-rotatably connected to the rotor (2; 32).

15. A seatbelt retractor according to one of claims 1 to 14 characterized in that the rotor (2; 32) is of a cap-shaped configuration and encloses the stator (3) and the planetary transmission arrangement (10; 12).

16. A seatbelt retractor according to claim 15 characterized in that the drive spring (5) is arranged within the cap-shaped rotor (2; 32).

17. A seatbelt retractor according to claim 15 or claim 16 characterized in that the drive spring (5) is arranged at the outside of the cap-shaped rotor (2; 32) and is non-rotatably connected by the spring core portion (13) to the axial extension portion (17), which is guided through the rotor (2; 32), of the torsion bar (6).

18. A seatbelt retractor according to one of claims 1 to 17 characterized in that the torque supplied by the electric motor (1) can be transmitted by a clutch (14; 15) to the torsion bar (6) and/or the belt reel (4).

19. A seatbelt retractor according to claim 18 characterized in that the clutch (14; 15) can be engaged for a combined load-limiting effect of torsion bar (6) and electric motor (1).

20. A seatbelt retractor according to one of claims 1 to 19 characterized in that the electric motor (1) is actuable in dependence on a pre-crash sensor and/or crash related data and/or vehicle occupant related data and/or belt webbing-wearing comfort.

21. A seatbelt retractor according to one of claims 1 to 20 characterized in that the rotor (2; 32) is selectively controllable in driving relationship

with the drive spring (5), the torsion bar (6) and the belt reel (4).

22. A seatbelt retractor according to one of claims 1 to 21 characterized in that a self-locking retaining device (36) operatively acts on the rotor (32).

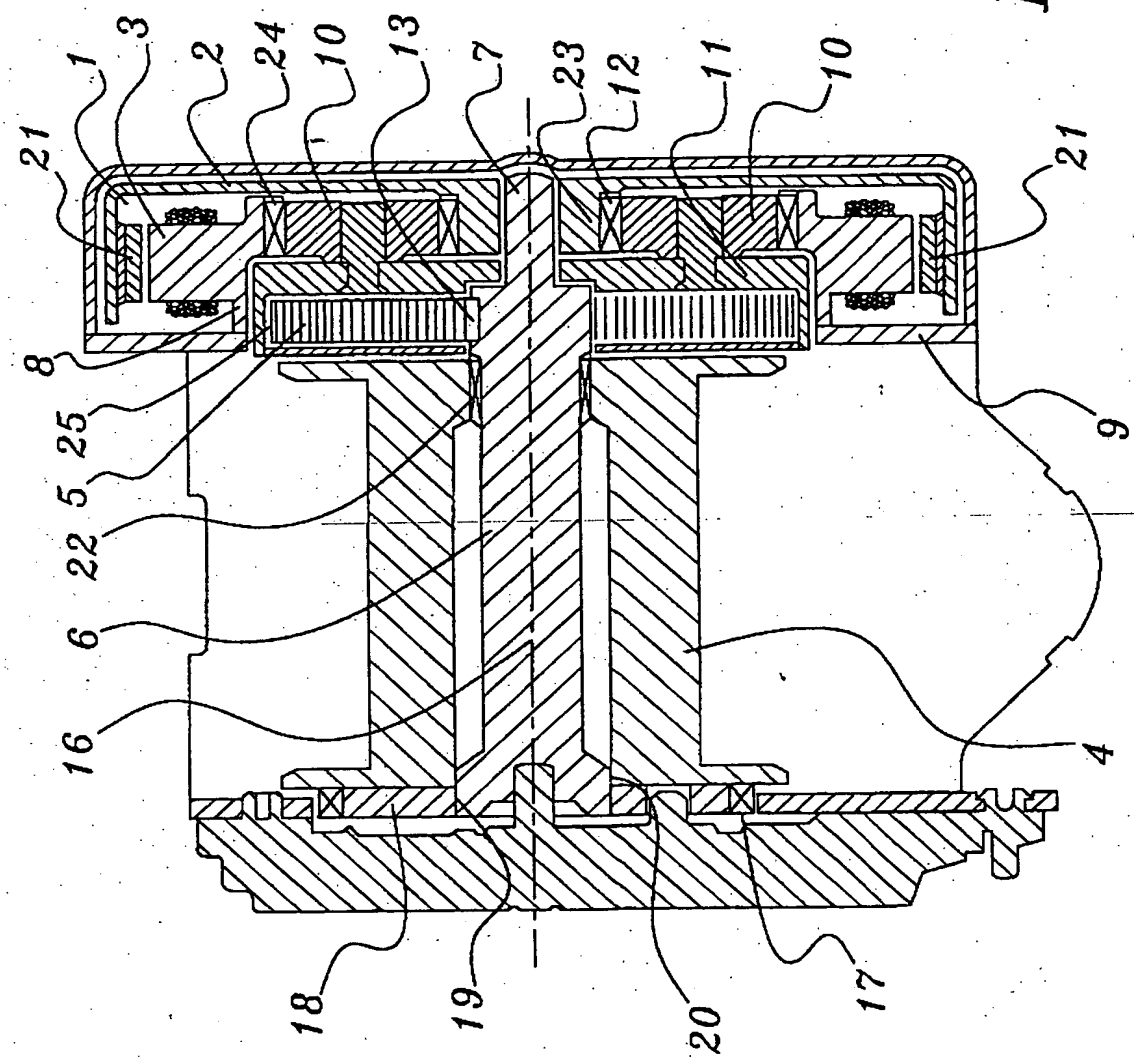

FIG. 1

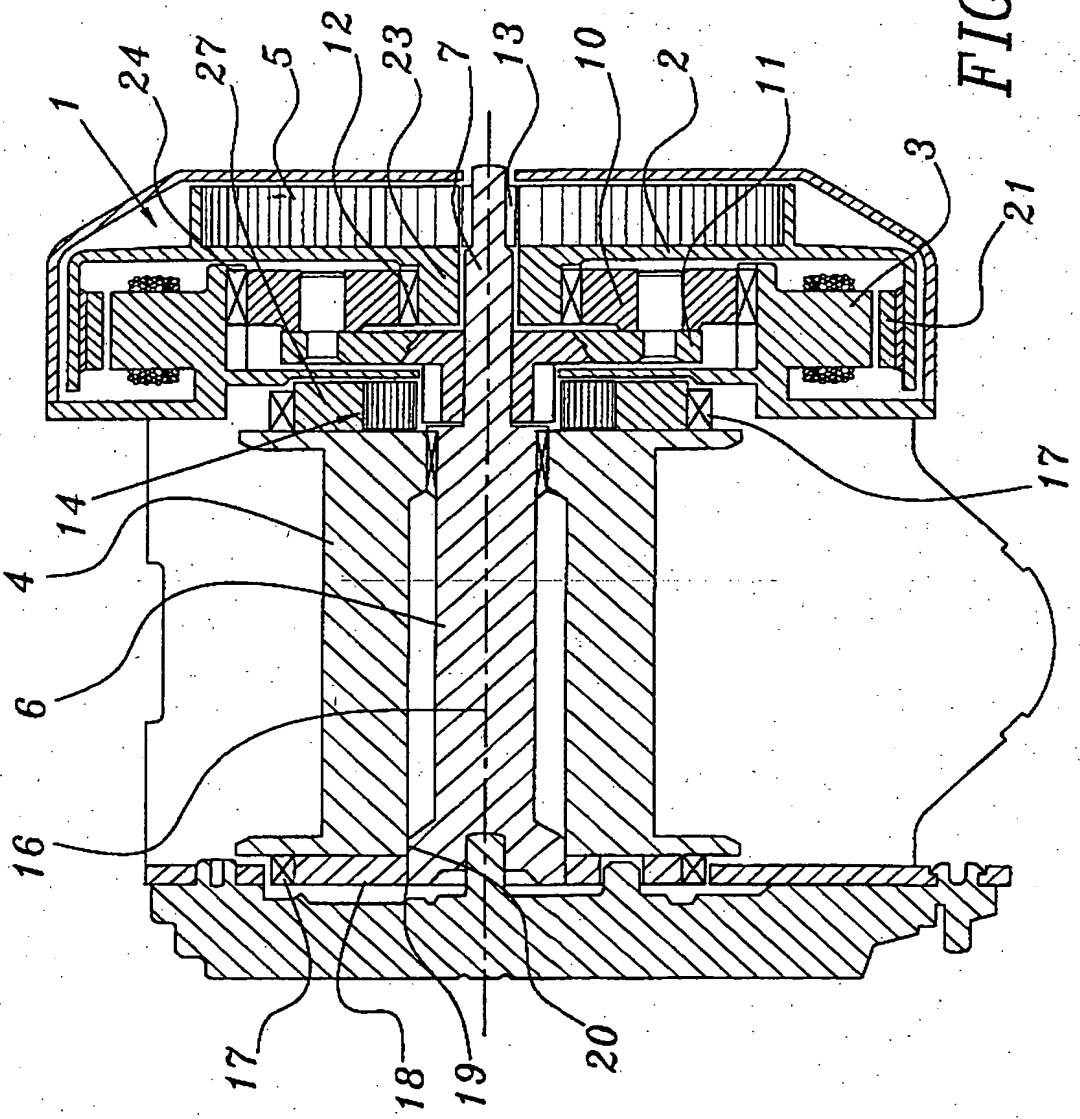

FIG. 2

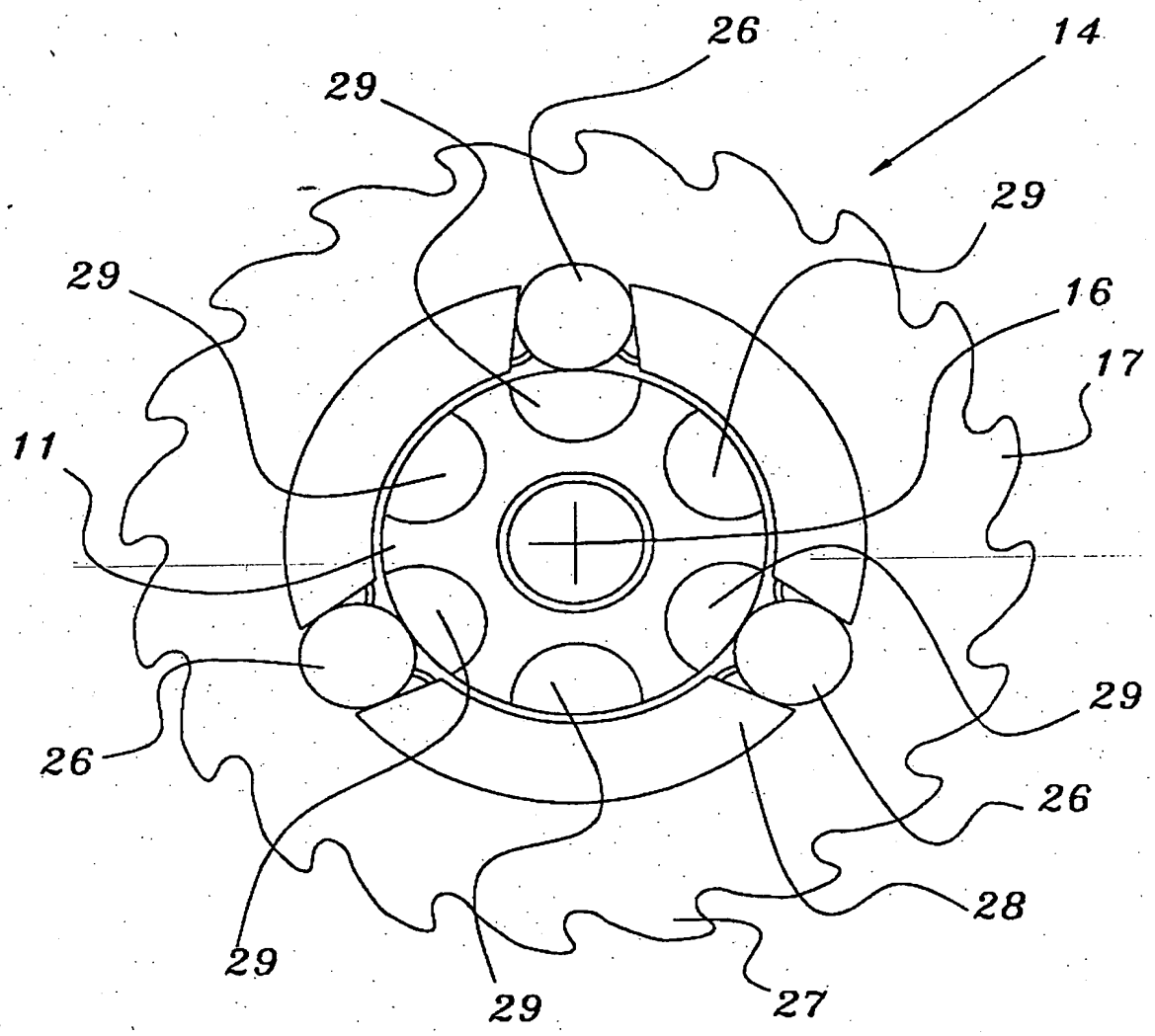

FIG. 3

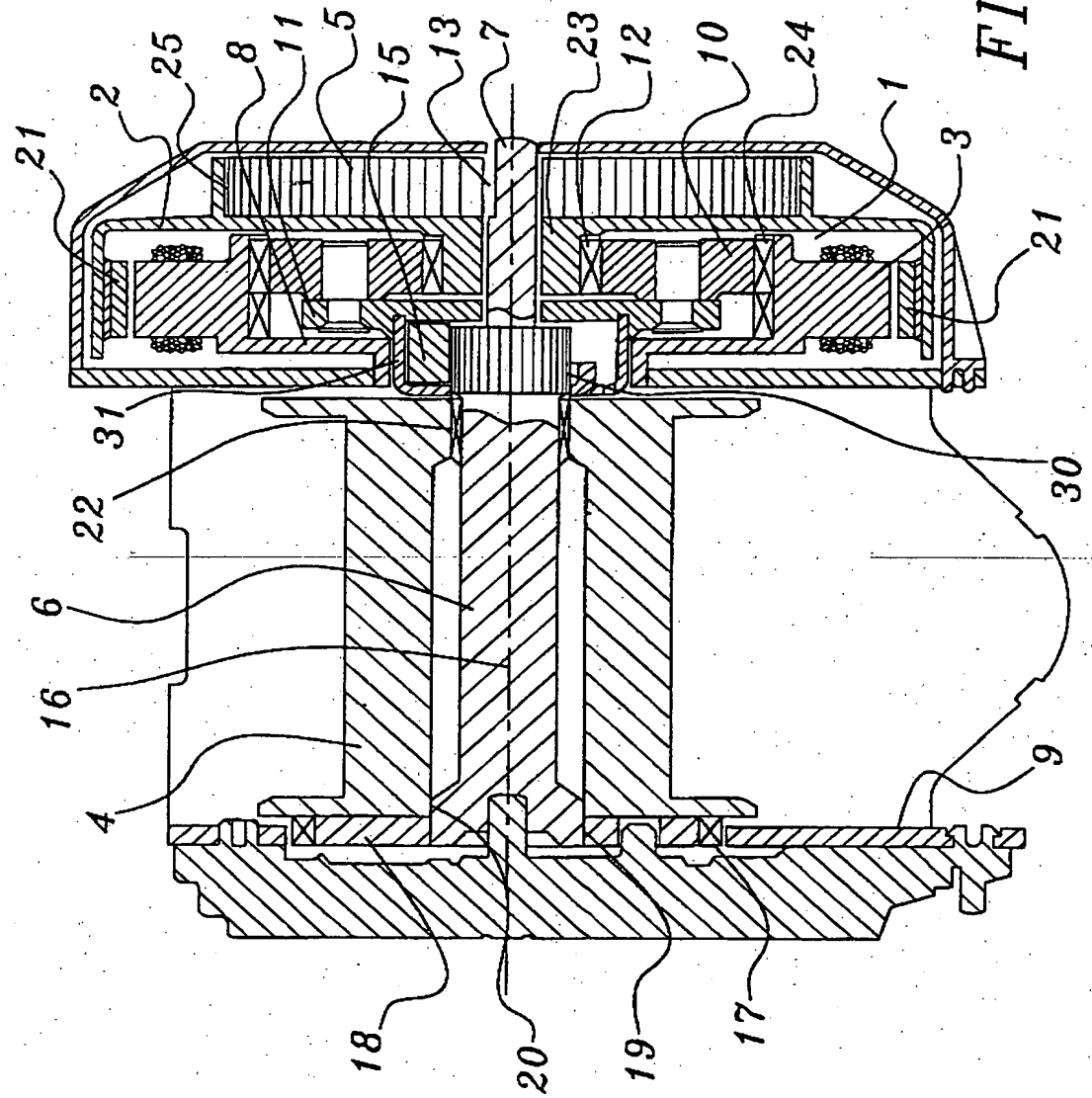

FIG. 4

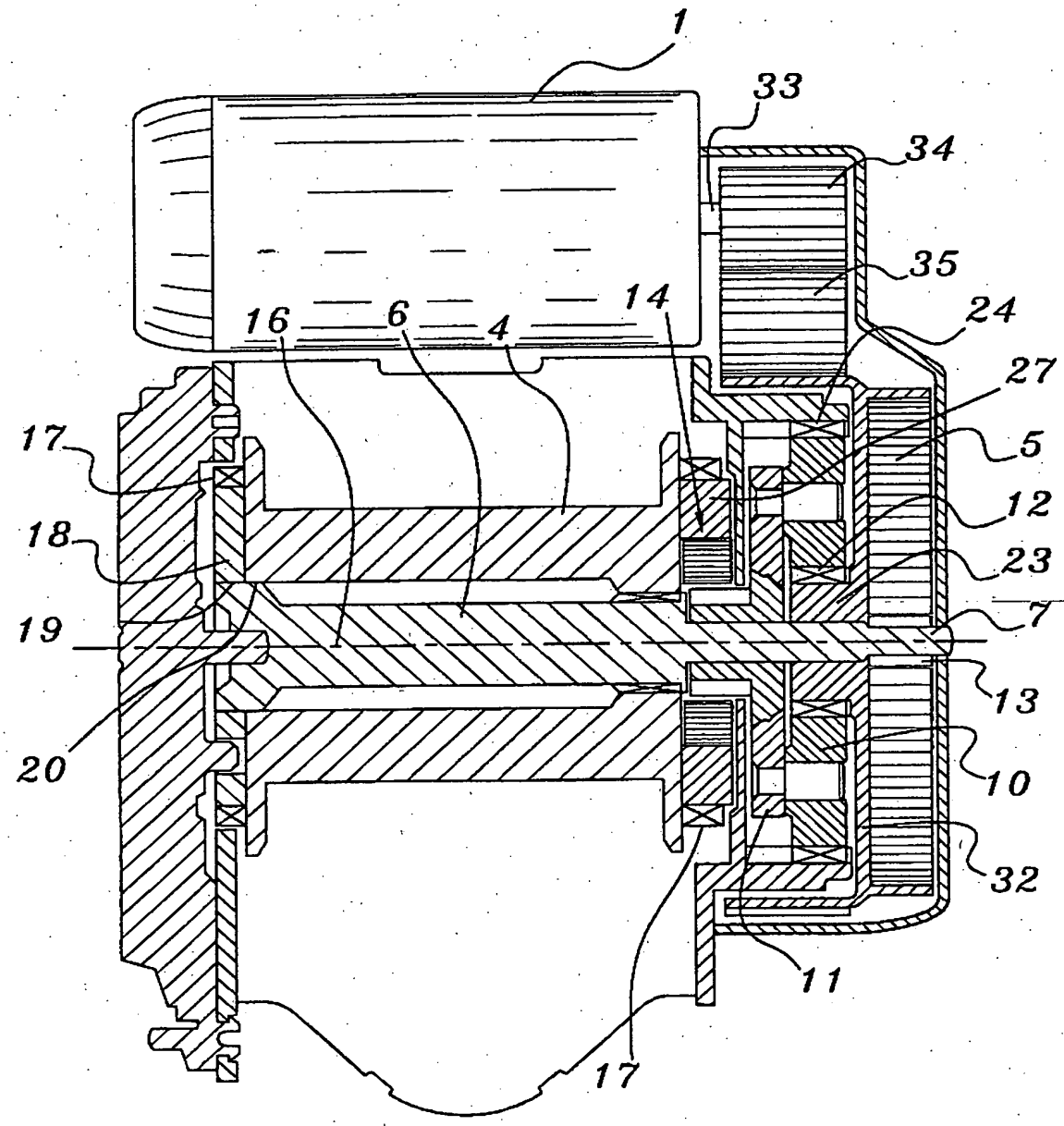

FIG. 5